Large scale non-linear learning on a single CPU

Andreas Mueller
NYU / scikit-learn

- Large Scale – “Out of core: Fits on a hard disk but in RAM” (500GB – 5TB?)
- Non-linear – because real-world problems are not.
- Single CPU – Because parallelization is hard (and often unnecessary)

Nobody ever got fired for using Hadoop on a cluster

Antony Rowstron, Dushyanth Narayanan, Austin Donnelly, Greg O'Shea, and Andrew Douglas

10 April 2012

- Why not to do out of core learning
- The scikit-learn way
  - Hashing trick
  - Kernel approximation
  - Random neural nets
  - Supervised Feature Extraction
  - Neural nets
- What else is out there

Why not do to out of core learning.

Your data is not that big!

	vCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
Memory Optimized - Current Generation					
r3.large	2	6.5	15	1 x 32 SSD	$0.195 per Hour
r3.xlarge	4	13	30.5	1 x 80 SSD	$0.39 per Hour
r3.2xlarge	8	26	61	1 x 160 SSD	$0.78 per Hour
r3.4xlarge	16	52	122	1 x 320 SSD	$1.56 per Hour
r3.8xlarge	32	104	244	2 x 320 SSD	$3.12 per Hour
Storage Optimized - Current Generation					
i2.xlarge	4	14	30.5	1 x 800 SSD	$0.938 per Hour
i2.2xlarge	8	27	61	2 x 800 SSD	$1.876 per Hour
i2.4xlarge	16	53	122	4 x 800 SSD	$3.751 per Hour
i2.8xlarge	32	104	244	8 x 800 SSD	$7.502 per Hour

"256Gb ought to be enough for anybody."
- me

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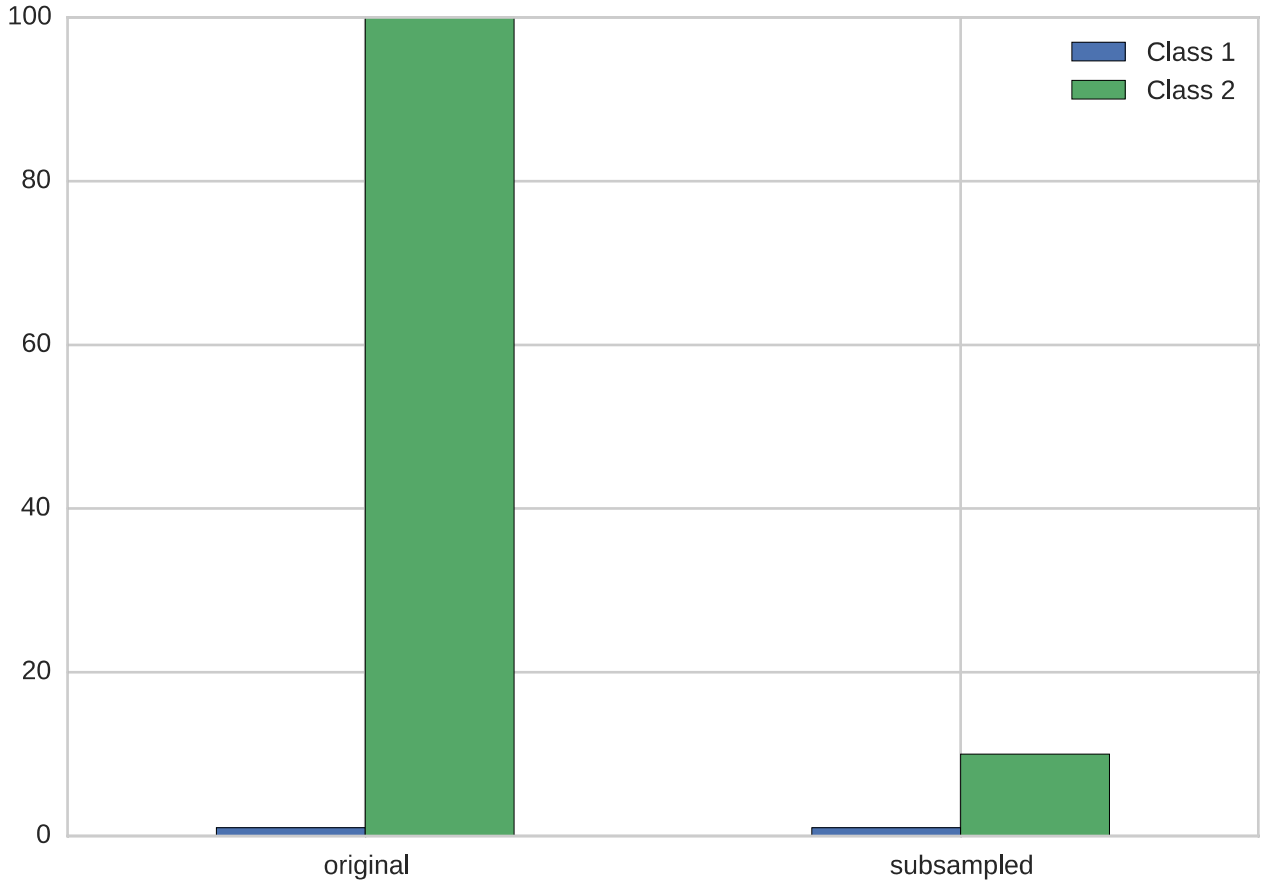
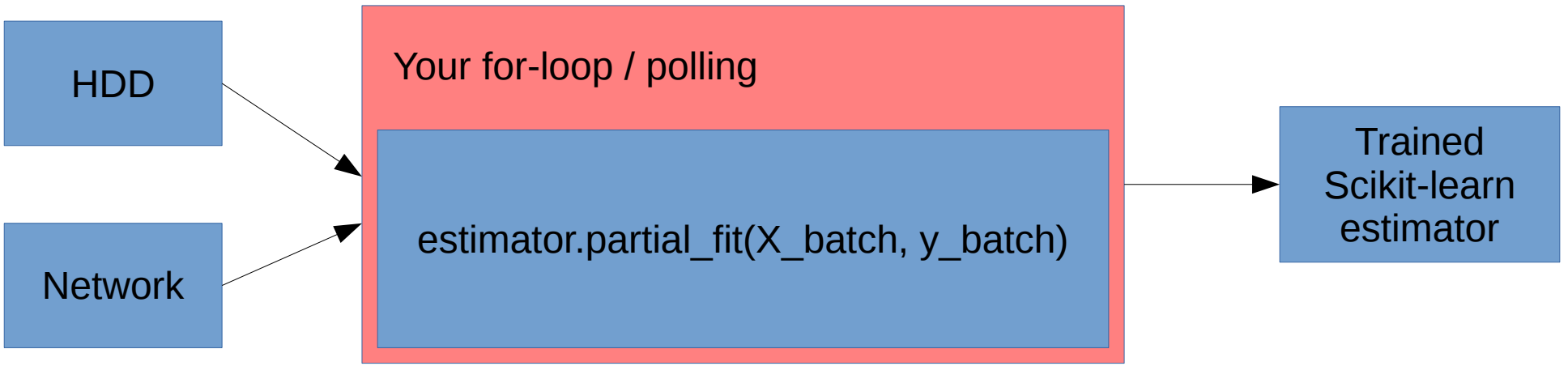
- me

(for machine learning)

Subsample!



The scikit-learn way


HDD
Network
Your for-loop / polling
estimator.partial_fit(X_batch, y_batch)
Trained
Scikit-learn
estimator

Linear Classification

```
from sklearn.linear_model import SGDClassifier

sgd = SGDClassifier()

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
        sgd.partial_fit(X_batch, y_batch, classes=[0, 1])
```

Linear Classification

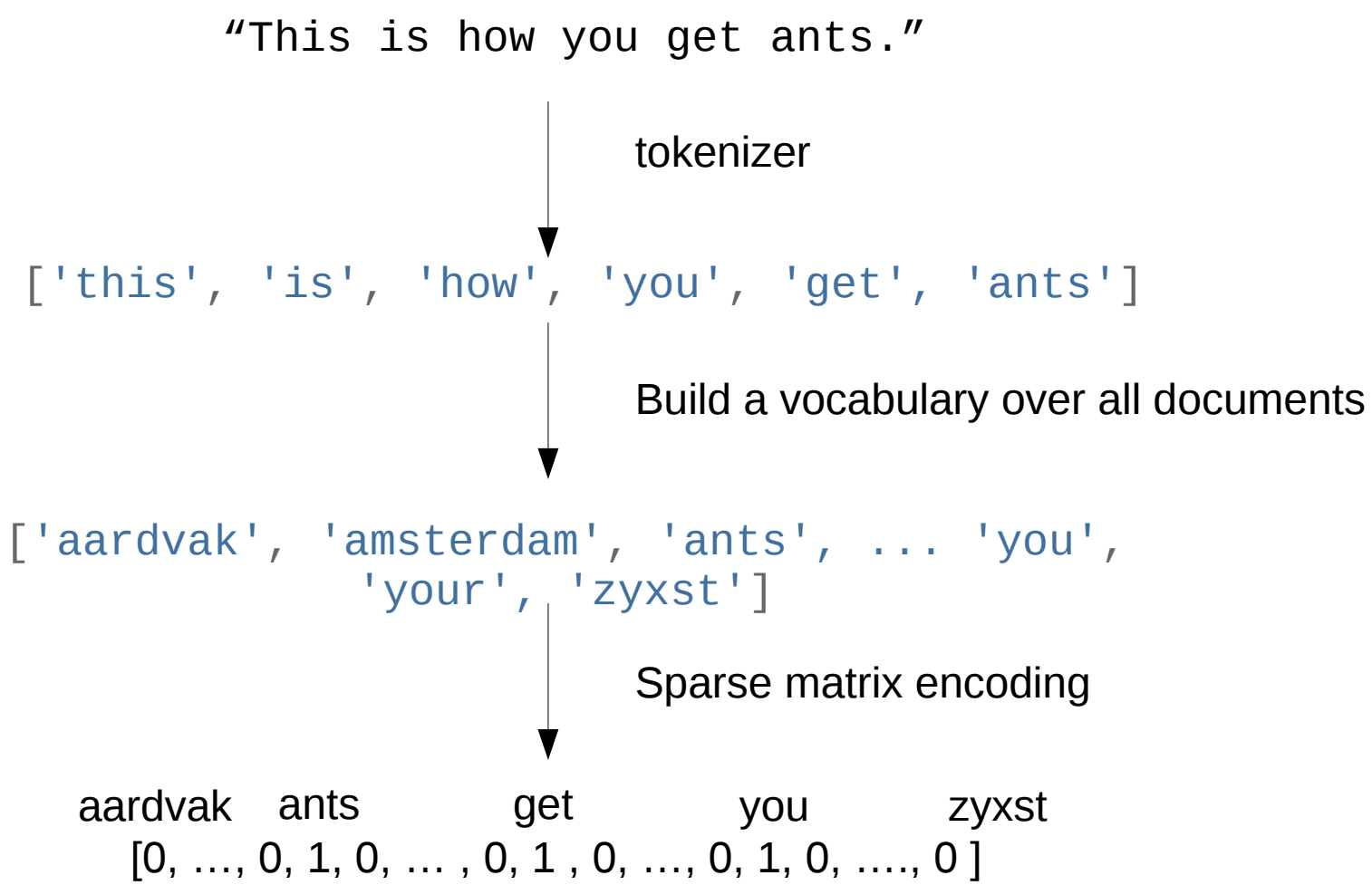
```
from sklearn.linear_model import SGDClassifier

sgd = SGDClassifier()

csv_iterator = pd.read_csv("my_large_file.csv", chunksize=10000)
for chunk in csv_iterator:
    X_batch = csv_iterator[features]
    y_batch = csv_iterator["label"]
    sgd.partial_fit(X_batch, y_batch, classes=[0, 1]
```

Linear Classification

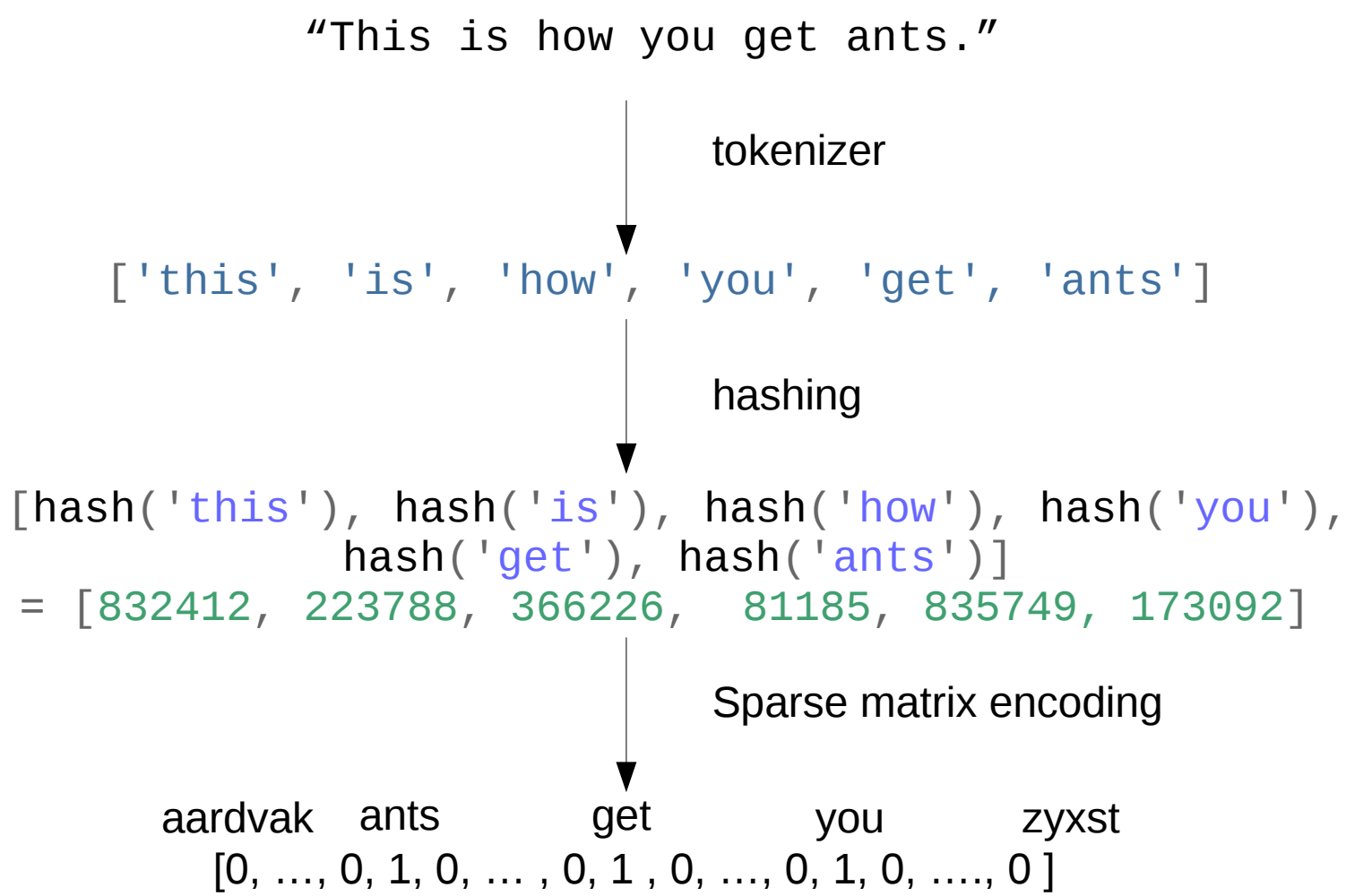
```
from sklearn.linear_model import SGDClassifier

sgd = SGDClassifier()

for i in range(n_iter):
    for batch_name in glob("*.pickle"):
        with open(batch_name) as f:
            X_batch, y_batch = pickle.load(batch_name)
            sgd.partial_fit(X_batch, y_batch, classes=[0, 1])
```

1st nonlinear option: Stateless Transformers

Text Classification: Bag Of Word



Text Classification: Hashing Trick



Text Classification: Hashing Trick

```
sgd = SGDClassifier()
hashing_vectorizer = HashingVectorizer()

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        text_batch, y_batch = pickle.load(batch_name)

    X_batch = hashing_vectorizer.transform(text_batch)
    sgd.partial_fit(X_batch, y_batch, classes=[0, 1]
```

Kernel Approximation

```
sgd = SGDClassifier()
kernel_approximation = RBFSampler(gamma=.001, n_components=400)
kernel_approximation.fit(np.zeros(1, n_features))

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
    X_kernel = kernel_approximation.transform(X_batch)
    sgd.partial_fit(X_kernel, y_batch, classes=[0, 1])
```

Random Neural Nets

```
sgd = SGDClassifier()
random_basis = RandomBasisFunctions()
random_basis.fit(np.zeros(1, n_features))

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
    X_random = random_basis.transform(X_batch)
    sgd.partial_fit(X_random, y_batch, classes=[0, 1])
```

(not merged yet)

2^{nd} nonlinear option:
Learn Transformations on Subsets

RandomForests

```
from sklearn.ensemble import RandomForestClassifier

X, y = load_my_subset_that_fits_in_ram()
rf = RandomForestClassifier(max_depth=5, n_estimators=100).fit(X, y)

rf_enc = OneHotEncoder()
rf_enc.fit(rf.apply(X))

sgd = SGDClassifier()

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
    X_transformed = rf_enc.transform((rf.apply(X_batch)))
    sgd.partial_fit(X_transformed, y_batch, classes=[0, 1])
```

3rd nonlinear option:
Online Nonlinear Classification

Neural Networks (MLPs)

```
sgd = SGDClassifier()

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
        sgd.partial_fit(X_batch, y_batch, classes=[0, 1])
```

(not merged yet)

Neural Networks (MLPs)

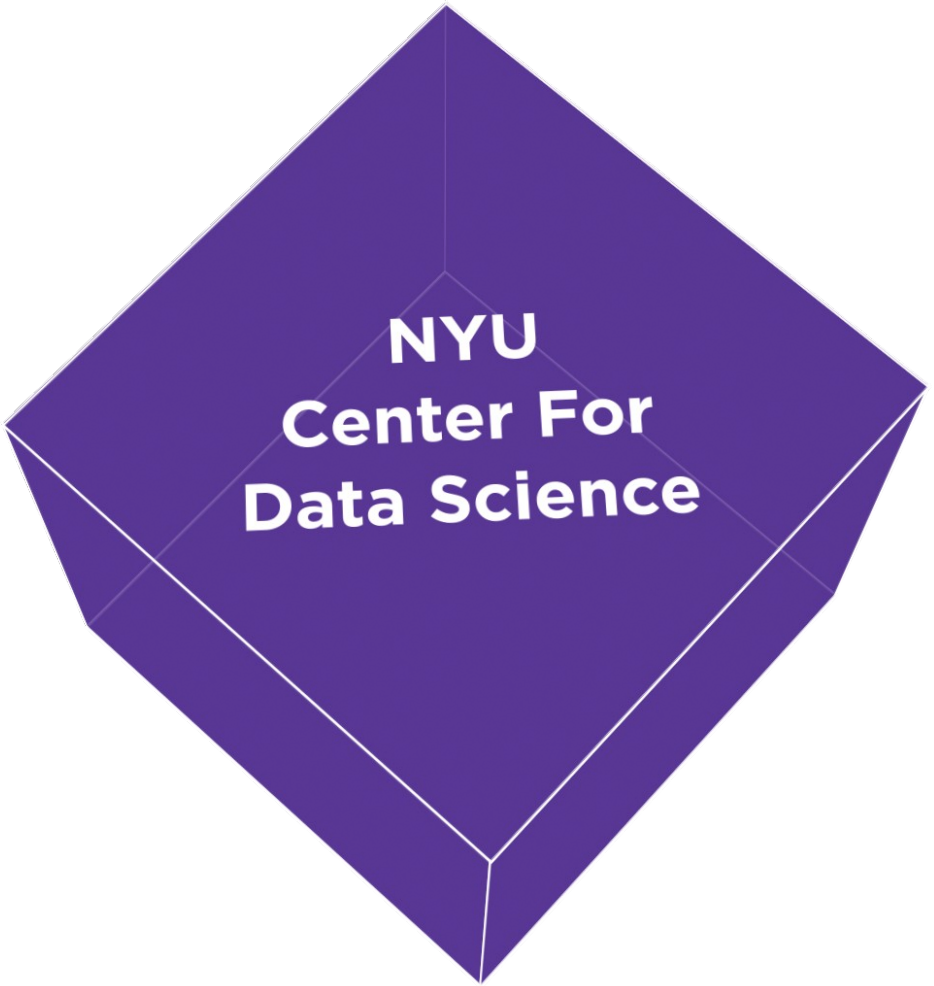
```
nn = MLPClassifier(n_hidden=(1000, 1000))

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
        nn.partial_fit(X_batch, y_batch, classes=[0, 1])
```

(not merged yet)

What Else is Out There?

- Vowpal Wabbit (VW)
- More deep learning
- Hogwild!

CDS is hiring Research Engineers

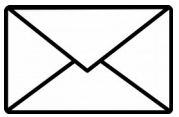


Thank you!

(and talk to me if you still think you need a cluster for ML)

@t3kcit

@amueller



t3kcit@gmail.com